Factors Affecting the Rutin Contents of Dried Buckwheat Meals*

The distribution of rutin in Tartary and Japanese buckwheat was determined at three ages of the plant. Fractional drying and screening produce a leaf meal of high rutin content. Wilting in the sun was evaluated as an adjunct to artificial drying of buckwheat for production of dried meals.

INVESTIGATIONS of domestic plants containing rutin revealed that buckwheat contains enough to be a commercial source of the glycoside. Preliminary studies (2) showed that the major portion of the rutin was in the leaves and blossoms of the immature plant and that the stems contained only a small fraction. These results suggested that rutin could be concentrated by the preparation of a leaf meal. It was possible to separate the buckwheat plant into leaf and stem fractions by applying the principles used in the preparation of leaf meals from vegetable wastes (1). In that procedure, the plant is dried until the leaves are brittle, and then the leaves are separated from the partly dried stems by screening. It was found that rutin is easily destroyed and that the drying process has to be carried out under strictly controlled conditions. Eskew and co-workers investigated this problem and worked out in detail the procedure for producing a dried leaf meal (4, 5, 7). They found that even under the best conditions of fractional drying, 25 to 35 per cent of the rutin was lost. When the buckwheat was totally dried, the destruction was somewhat greater.

In a study of the influence of various agronomic factors on the rutin content of buckwheat, it was discovered that the Tartary variety (*Fagopyrum tataricum*) was richer in rutin than the Japanese (*F. esculentum*) (3). Since the former variety appeared to be richer in leaf material, a study was undertaken to determine the distribution of rutin in the buckwheat plant and the factors that influenced this relationship. Another factor studied was the effect of wilting or sun-drying on the rutin content of dried buckwheat.

* Received June 23, 1950, from the Eastern Regional Research Laboratory, Philadelphia 18, Pa., one of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Dept. of Agriculture.

† The authors thank C. S. Fenske, Jr., and Ralph Bruch for technical assistance and R. K. Eskew, N. C. Aceto, Rita Hurley, and G. W. M. Phillips for making available leaf meals prepared during their study of drying conditions.

DISCUSSION OF EXPERIMENTS

Distribution of Rutin in the Buckwheat Plant.—Tartary and Japanese buckwheat were grown on well-fertilized soil with the plants spaced at 2-in. intervals in rows 12 in. apart. The harvested green plants were separated into two fractions: (*a*) stems, and (*b*) leaves and blossoms. Petioles were considered as part of the leaves, since they are not separated from the leaves by the mechanical separation (4). The samples were analyzed for crude or corrected rutin by the method of Naghski, *et al.* (6). Table I shows the results obtained at three ages. About 81–89% of the rutin is localized in the leaves and blossoms, which constitute from 45 to 70% of the dry weight of the plant, depending on its age. The leaf fraction from the Tartary buckwheat is richer in rutin than that from the Japanese. The data in Table I show that, at the proper age of the plant, the rutin can be concentrated as much as 78% by discarding the stems. This value, of course, is theoretical, and would not be attained in a mechanical process. During the course of this study, numerous buckwheat leaf meals and corresponding fresh plants were analyzed. Since only limited data are available in the literature on how effectively rutin is concentrated by producing leaf meals, some results obtained with selected samples are presented in Table II.

Since corresponding whole meals were not available for analysis, the rutin content was approximated by calculation on the basis of discarding 37% of the dry weight as stems containing 0.3% rutin. Although the quantity of stems removed in individual runs will vary from 37%, the expected average for commercial production will be near this value, which Phillips, *et al.* (7), found to be the average value from a number of typical runs. The value of 0.3% for the rutin content was the average of a number of dried and partially dried stems (6). Individual samples ranged from 0.0 to 0.57% rutin.

On this basis, the leaf meals were about 50% richer in rutin than the corresponding meals made from the whole plant. This richer meal increased the capacity of the equipment for extracting rutin. Furthermore, in fractionally dried plants, this concentration was more than sufficient to offset the loss of rutin incurred in the drying process, since the leaf meal was richer in rutin than the starting fresh plant. When the plant was totally dried, the loss of rutin caused by drying was higher, and the leaf meal produced did not have as high a rutin content as the fresh plant. Leaf meals containing 4 to 5% rutin can be produced easily, and leaf meals containing as much as 6.7% rutin have been produced at this laboratory. Meals of this quality would probably compete favorably with some of the newer sources of rutin, now imported in limited commercial quantities.

TABLE I.—DISTRIBUTION OF RUTIN IN TARTARY AND JAPANESE BUCKWHEAT PLANTS AT DIFFERENT AGES[a]
(Average Values on Moisture-Free Basis)

Age, Days →	31		38		45	
Species →	Tartary	Japanese	Tartary	Japanese	Tartary	Japanese
Whole Plant						
Moisture, %	92.0	91.4	92.1	88.5	86.7	83.0
Dry weight of plant, Gm.	1.0	1.6	1.9	3.2	4.8	7.7
Crude rutin, %	3.8	3.3	4.3	2.7	3.6	1.9
Crude rutin, mg./plant	38.0	52.8	81.7	86.4	172.8	146.3
Leaves and blossoms, % of whole plant	70	60	56	51	45	53
Leaves and Blossoms						
Moisture, %	88.1	87.5	89.3	85.5	85.6	81.6
Crude rutin, %	4.7	4.5	6.3	4.7	6.4	3.2
Crude rutin, mg./plant	32.9	43.7	66.2	76.6	139.5	129.3
Crude rutin, % of total in plant	87	83	81	89	81	88
Increase in concentration of rutin over that in whole plant, %	24	36	47	74	78	68

[a] Plants grown near Philadelphia in 1946. Fertilized at rate of 1,000 lb. of 5–10–5 per acre.

Similar results were obtained with the Japanese variety. Since it is not as rich in rutin as the Tartary variety, however, and it is not being used commercially, the data are not presented.

Effect of Wilting or Sun-drying on Rutin Content of Buckwheat.—Since artificial drying is expensive, the effect of sun-drying was investigated. Unlike most plants, buckwheat does not sun-cure readily. Although the leaves dry quickly, the stems retain their moisture for a long time. Samples[1] of whole Tartary plants were exposed to sunshine for three days. At the end of each day, the plants were separated into a leaf fraction and a stem fraction, and oven-dried. Table III shows the moisture contents.

TABLE II.—RUTIN CONTENT OF LEAF MEAL PRODUCED BY FRACTIONAL AND TOTAL DRYING OF TARTARY BUCKWHEAT PLANTS[a]
(Moisture-Free Basis)

Sample No.	Corrected Values for Rutin in—Fresh Plant (A), %	Leaf Meal (B), %	Whole Meal[b] (C), %	Increased Concn. of Rutin in Leaf Meal,[c] %
Fractionally Dried				
1	4.64	4.89	3.19	53
2	5.22	5.38	3.50	54
3	3.97	3.26	2.16	51
4	4.49	4.74	3.10	53
5	3.49	3.53	2.33	52
Totally Dried				
6	3.89	3.46	2.29	51
7	4.81	4.03	2.65	52
8	2.89	1.73	1.20	44
9	3.28	3.15	2.09	51

[a] Samples obtained during the investigations on buckwheat drying by Phillips, *et al.* (7).
[b] Calculated on the basis of discarding 37% of the dry weight as stems containing 0.3% rutin.
[c] $\frac{B - C}{C} \times 100$.

TABLE III.—EFFECT OF SUN-DRYING ON MOISTURE CONTENTS OF TARTARY BUCKWHEAT PLANTS[a]

Time Exposed to Sun, Hr.	Moisture Content of—Leaves, %	Stems, %	Whole Plant, %
0	87.5	93.3	91.3
7.5	24.4	88.2	79.5
15.5	13.0	85.5	75.2
20	12.1	85.0	73.3

[a] Experiment conducted September 12–14, 1947.

The results show how misleading the over-all moisture can be in regard to the dryness of the plant. The most rapid drying took place during the first day, and the greatest loss of moisture was in the leaves. The ratio of leaf to stem (dry weight) in these plants was 1:1, indicating the magnitude of loss of moisture from the leaves. The significance of this in the drying of buckwheat, especially in the preparation of leaf meal, is self-evident.

Another experiment was conducted to compare the rate of drying of young and old buckwheat plants. The old plants were badly lodged, so that

[1] In each wilting experiment described in this paper, replicate 200.0-Gm. samples were used.

TABLE IV.—EFFECT OF SUN-DRYING ON MOISTURE CONTENTS OF LEAVES AND STEMS OF OLD AND YOUNG TARTARY BUCKWHEAT PLANTS[a]

Time Exposed		Moisture Content of—Young Plants			Old Plants		
Sun, Hr.	Dark, Hr.	Leaves, %	Stems, %	Whole Plant, %	Leaves, %	Stems, %	Whole Plant, %
0	0	79.6	93.6	89.6	78.5	77.6	77.9
0	24[b]	36.8	90.3	86.5	45.7	65.0	61.7
6	0	37.0	90.1	83.8	29.7	66.0	55.6
12	16[c]	59.5	87.9	82.6	14.3	66.0	51.0

[a] Experiment conducted September 16–17, 1947.
[b] Dried at room temperature.
[c] Heavy dew during night.

only the top (18–24 in.) was suitable for use. Samples were exposed to the sun, then separated into leaf and stem fractions. The seeds in the old sample gave a little trouble after sun-drying, since they nded to drop off into the leaf fraction. The results re presented in Table IV.

The weather was not as hot as it was the previous week, and this is reflected in the poorer drying of the plants. A comparison can be made, however, between the rates of drying at the two ages of the plants. The leaves on the older plant, being smaller and thinner, dried much more rapidly. The stems from both ages dried at approximately the same rate.

Two experiments (Table V) showed that there was no appreciable loss of rutin during the exposure to sun for one or two days. However, plants that accidently were exposed to rain for thirty-eight hours before they were completely dry, lost almost 40% of their rutin when they were again exposed to sunshine. In this case, rain restored the leaves to normal turgor, and they evidently respired actively when subsequently exposed to sunlight, making the rutin susceptible to destruction.

TABLE V.—EFFECT OF SUN-DRYING ON MOISTURE AND RUTIN CONTENTS OF JAPANESE BUCKWHEAT PLANTS

Time Exposed			Crude Rutin[a]		
Sun, Hr.	Dark, Hr.	Moisture, %	A, %	B, %	Av. %
		July 10–12, 1946			
0	0	86.8	3.28	2.80	3.04
0	5	86.7	3.60	3.29	3.44
1	0	86.3	3.67	3.36	3.52
3	0	83.5	3.41	3.37	3.39
5	0	82.8	3.04	2.83	2.94
5	17	83.9	3.36	3.46	3.41
12	17	77.3	2.72	3.09	2.91
12	35	77.5	3.01	3.00	3.01
		August 6–8, 1946			
0	0	91.6	2.84	3.00	2.92
1	0	89.4	3.13	2.86	3.00
3	0	89.4	3.21	2.60	2.91
5	0	88.2	3.15	2.88	3.02
5	21[b]	90.3	3.06	3.67	3.37
13	38[b]	84.2	1.96	2.15	2.06

[a] Moisture-free basis.
[b] Continuous rain.

In another experiment, the plants were spread out in the dark for nineteen hours before exposure to sunlight. The results presented in Table VI show that after this treatment rutin was destroyed rapidly. Evidently the plant must be dried rapidly (especially the leaves) if rutin is to be preserved.

Investigation of large-scale wilting under field conditions was made by Phillips, *et al.* (7). They found that, under optimum conditions, wilting removes from one-third to one-half the moisture without any appreciable loss of rutin. If as much as one-half the moisture was removed, however, excessive loss of rutin occurred on drying. There were indications that wilting done too slowly destroyed considerable rutin. Although it is difficult to obtain uniform exposure to sunlight under field conditions, as pointed out by Phillips, *et al.*, their results agree closely with our laboratory-scale experiments cited above.

TABLE VI.—EFFECT OF STORING TARTARY BUCKWHEAT PLANTS IN THE DARK BEFORE SUN-DRYING ON RUTIN CONTENT

Time Exposed to Sun,[a] Hr.	Crude Rutin[b] A, %	B, %	Av., %	Apparent Loss, %
0	3.75	4.26	4.01	...
7.5	2.48	2.52	2.50	37.5
15.5	1.61	1.45	1.53	62.0

[a] Plants stored for nineteen hours in dark at room temperature before exposure to sunlight (September 12–14, 1947).
[b] Moisture-free basis.

SUMMARY

About 80 to 90 per cent of the rutin of the buckwheat plant is localized in the leaves and blossoms, which constitute from 45 to 75 per cent of the dry weight of the plant. Fractional drying produces a leaf meal with 50 per cent higher rutin content than corresponding whole plant meals. Wilting in the sun, if controlled carefully, can be a valuable adjunct to artificial drying of buckwheat for production of dried meals.

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